International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 12 | Dec -2016 www.irjet.net p-ISSN: 2395-0072

A Novel method for image enhancement by Channel division method using Discrete Shearlet Transform and Genetic Algorithm

S.Prem kumar [1], K.A.Parthasarathi [2]

[1] *Research Scholar, St.Peter's University, Chennai. premkumarsvcoe@yahoo.co.in*
[2] *Principal, Aksheyaa college of Engineering, Chennai. kaps_wwh2003@yahoo.com*

---***---

Abstract - *Image enhancement plays a vital role in image processing technique. This paper presents a Novel method for image enhancement by channel division method using discrete shearlet transform and genetic algorithm. In this proposed algorithm, the RGB image converted into HSI (Hue, Saturation and Intensity) model, where as Intensity and Hue colour considered for Image enhancement after conversion. The Hue component decomposed into directional co-efficient by discrete shearlet transform. The higher directional coefficients are eliminated as it causes artifact and unnatural efforts in a image and the intensity components of image is contrast enhanced by using Genetic Algorithm. The performance of the proposed image enhancement method is compared with existing histogram equalization and discrete shearlet transform based image enhancement. The result of the proposed method achieves satisfactory performance in visualization.*

Key Words: Channel division method, Discrete Shearlet Transform, Higher directional co-efficient, Genetic Algorithm.

1.INTRODUCTION

Contrast enhancement, a process applied on image to increase their dynamic range. This can be done using several contrast image enhancement techniques. An effective and simple algorithm for this purpose is histogram equalization[1]. An improved version of histogram is adaptive histogram equalization techniques has been proposed[2], which brings a limited improved, because fixed contextual regions cannot adapt to features of different size. To overcome this limitations another, more advanced enhancement algorithms Automatic weighting mean separated histogram equalization and is only suitable for gray scale image Consequently, more complex method is the multi scale retinex (MSR) algorithm[4]. The fast version of the MSR [4] is defined by

$$Ie = \sum_{n=1}^{N}(log(I) - log(LPFn(I))) \qquad - (1)$$

Where LPFn(.) is the n^{th} low pass spatial filtering function. I is the image to be enhanced, I_e is the enhanced image. Several methods are proposed [5]-[8] to improve image enhancement by using MSR [4] nevertheless, method based on the MSR have high computational complexity. Another widely used method is image enhancement by using Directional Wavelet Transform [9], which has two disadvantages of shift invariance and poor directional selectivity for diagonal features. Another efficient method is enhancement using Discrete Shearlet Transform [10] and is only enhanced the contrast colour of an image.

Different Genetic approaches have been applied for image contrast enhancement [11]-[13]. The proposed method in [11], is based on a local enhancement technique. In this method transformation function is adapted using a genetic algorithm. In another genetic approach, the relations between input and output gray levels are represented by a lookup table (LUT) [12]. These relations between gray levels are determined based on a curve by a Genetic Algorithm.

An effective Genetic Algorithm approach is based on a simple chromosome structure and the Genetic Algorithm [13], is used to find the best gray level to enhance the original image. In this paper we proposed an novel method for contrast image enhancement method based on Discrete Shearlet Transform and Genetic Algorithm.

This paper is organized as follows section II describes the channel division method, Section III explains the Genetic approaches for proposed method, Section IV gives an introduction to DST. Section V gives details of proposed approach is presented. Section VI presents results that illustrate the effectiveness of the method and compared with previous methods. Finally we conclude this paper in section VII.

2.CHANNEL DIVISION METHOD

Channel division method is the process of merging the Local Contrast Indicator (LCI) i.e. grouping contrast pairs in to channels. To do this first the original image is split into regions of hue (H), saturation (S), intensity (I) using ad hoc transformation which is based on information from contrast of textured and boundary regions. Proposed algorithm is only applied to the Hue and Intensity (I) region and at the same time Saturation is maintained constant until merging. Contrast is coded by contrast pairs because of its inspiration so that it spreads over the dynamic range of intensities. Intensity channels are building blocks of region channel that can be used to control the interference and overlap of contrast pairs. In region channels, channels are grouped to simulate the human visual characteristics with a set of transformation functions which enhances the each image particular characteristics and merge the process results to reduce artifacts. To adjust final transformation for enhancing the image this method uses channel division and mixture process. Contrast pairs are used to model the intensity difference between two pixels.

3. GENETIC METHOD

3.1. Chromosome Structure

The proposed method uses a simple chromosome structure. An example of the chromosome structure has been shown in Fig.1.

0	**10**	**45**	**68**	**105**	**190**	**210**	**255**

Figure: 1. Chromosome structure with fitness values with n = 8

This structure uses a sorted array of random integer numbers. The size of each chromosome is equal to *n*, which *n* represents the number of gray levels in the input image. In the proposed structure, the indices indicate the order of gray levels in the image, for example the index 1 indicates the first gray level in the image and so on. For example, in Fig.1, the first gray level in the image is 0, the second one is 10, the third one is 45, and the last one is 255. In remapping, the first gray level in original image is replaced with the value of first cell of the enhanced chromosome and so on.

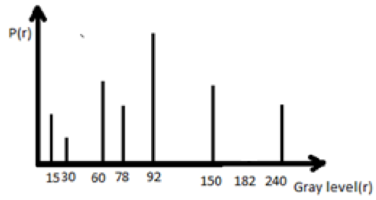
Based on the mentioned chromosome structure, remapping of the input gray levels is done by the following transformation:

$$T[r(k)] = C_i(k) \qquad - (2)$$

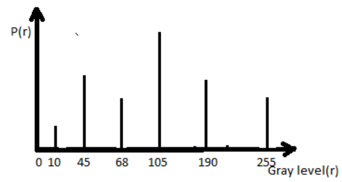
$$K = 1,2, \dots n$$

Where *T* is the function that used for changing the original image gray levels, *G* is the array of input gray levels in ascending order, *k* stands for number of gray levels in the input image and r(k) is k^{th} gray level of them, C_i represents the i^{th} chromosome in the population, and $C_i(k)$ represents the value of k^{th} cell.

An example of the proposed transformation has been shown in Fig.2. Fig.2 (a) shows the histogram of the input image. Fig.2 (b) is the result of gray level remapping. This remapping has been done based on the chromosome structure, which is shown in Fig.2 (c). Fig.2 (d) represents the array of input gray levels.



(a)



(b)

0	**10**	**45**	**68**	**105**	**190**	**210**	**255**

(c)

15	**30**	**60**	**78**	**92**	**150**	**182**	**240**

(d)

Figure: 2. (a) The histogram of the low-contrast image (b) The result histogram enhanced by GA (c) chromosome structure (d) The array of input gray levels

The remapping of the gray level values in the input image has been done as follows:
T(15)=0, T(30)=10, T(60)=45, T(78)=68, T(92) = 105, T(150)=190, T(182)=210, T(240) = 255

Initial population, may be generated through a random or user specified process. It plays an important role in search direction. A well selected initial population increases the search procedure convergence speed and results in faster trend to optimum solution. In the proposed method, to generate initial population, at first, the number of input gray levels (n) is calculated. After that, each chromosome is created by using the following steps. These steps should be repeated for population count.

1. For each chromosome, an array of random integer numbers with length *n* is generated. The first element of array is set to 0 and the last one is set to 255 to maximize the dynamic range of gray levels.

2. The created array in step (1) is sorted in ascending order. As mentioned earlier, this structure is used for remapping the input gray levels to new ones.

After constructing initial population, the fitness values for all individuals should be calculated. The number of individuals in the population is constant in all generations. Some individuals that have most fitness values are gone forward to next generation. If the crossover rate is called *Pc* and number of individuals is called *Ps*; number of individuals that are passed to next generation is equal to Ps - *Ps*Pc.* Therefore, the number of new generated individuals in each generation is *Ps*Pc.* These processes are performed while the terminating condition is not satisfied. Terminating criteria is a determined number of generations [13].

In the next sub sections, other parts of the genetic algorithm are described.

3.2. Fitness function

In the proposed method, the number of edges and their overall intensity are used as fitness value for each chromosome because a gray image with good visual contrast includes many intensive edges. This fitness function has been shown in equation

$$fitness(x) = log(log(E(I(x))*n\_edges(I(x))) \quad - (3)$$

Where *fitness(x)* denotes the fitness value of chromosome *x* and *I(x)* is the enhanced image. *n_ edges (I(x))* presents the number of detected edges in the enhanced image which is calculated by a Sobel edge detector. In (2), sum of the intensity values of the of the enhanced image, has been shown by *E(I(x))* which is calculated by the following expression

$$E\,(I(x)) = \sum_x \sum_y \sqrt{\delta h_1(x,y)^2 + \delta v_1(x,y)^2} \quad - (4)$$

Horizontal edge is detected by using:

$$\delta h_1(x, y = g_1(x+1, y-1) + 2\, g_1(x+1, y) + g_1(x+1, y+1) - g_1(x-1, y-1) - 2g_1(x-1, y) - g_1(x-1, y+1) \quad - (5)$$

Vertical edge is detected by using:

$$\delta v_1(x,y) = g_1(x-1, y+1) + 2g_1(x, y+1) + g_1(x+1, y+1) - g_1(x-1, y-1) - 2g_1(x, y-1) - g_1(x+1, y-1) \quad -(6)$$

-1	0	+1
-2	0	+2
-1	0	+1

$\delta h_1(x,y)$

(a)

+1	+2	+1
0	0	0
-1	-2	-1

$\delta v_1(x,y)$

(b)

Figure: 3. (a) Sobel operator for horizontal edge detection (b) Sobel operator for vertical edge detection.

In equation (2), a log-log measure of the edge intensity is used to prevent producing un-natural images.

3.3. Selection algorithm

Selection of the individuals is done based on the fitness value of the solutions. The probability of selection an individual is directly or inversely proportional to its fitness value. The roulette wheel selection is used in our proposed GA [13]. The main idea of this method is to select stochastically from one generation to create the next generation. In this process, the more appropriate individuals have more probability of survival and go forward to the next generation but the weaker individuals will also have a little probability to select.

In selection process, *Ps*Pc* individuals are selected for creating the same number individuals from them according to crossover.

3.4. Crossover and mutation operators

Because of constructing individual chromosomes based on a simple structure, complex cross over operators are not necessary. In the proposed method, two point crossover is used. Therefore, *Ps*Pc* individuals are selected according to our selection process where *Pc* is crossover rate. As *Ps*Pc* new individual is needed after doing crossover, two parents are selected and two new child are produced from them. Points in each parent are selected randomly and segments between these two points are substituted to produce new individual. Finally, each new individual is sorted in ascending order to preserve structure.

For each individual, a random number is produced, if it is lower than *Pm* (mutation constant), mutation will be done for that individual as mentioned follow. 5% of the individual chromosome elements are selected randomly for mutation. For each element a random integer number that should be less than or equal to the next element value and more than or equal to the previous element is generated. This random number is replaced by element.

4. DISCRETE SHEARLET TRANSFORM

The proposed contrast image enhancement is based on new multi-scale directional representations called the shearlet transform introduced in [11]. An $N*N$ image consists of a finite sequence of values, $\{x[n_1,n_2]_{n_1,n_2=0}^{N-1,N-1}\}$ where $N \in \mathbb{N}$. Identifying the domain with the finite group $\mathbb{Z}_N^2$, the inner product of image $x, y : \mathbb{Z}_N^2 \to \mathbb{C}$ is defined as

$$(x,y) = \sum_{u=0}^{N-1}\sum_{v=0}^{N-1} x(u,v)\overline{y(u,v)} \quad (7)$$

Thus the discrete analog of $L^2(\mathbb{R}^2)$ is $l^2\mathbb{Z}_N^2$. Given an image $f \in l^2(\mathbb{Z}_N^2)$, let $\hat{f}[k_1,k_2]$ denote its 2D Discrete Fourier Transform (DFT):

$$\hat{f}[k_1,k_2] = \frac{1}{N}\sum_{n_1,n_2=0}^{N-1} f[n_1,n_2]e^{-2\Pi i(\frac{n_1}{N}k_1+\frac{n_1}{N}k_2)} \quad (8)$$

The brackets in the equations $[\cdot,\cdot]$ denote arrays of indices, and parentheses $(\cdot,\cdot)$ denote function evaluations. Then the interpretation of the numbers $\hat{f}[k_1,k_2]$ as samples $\hat{f}[k_1,k_2] = \hat{f}(k_1,k_2)$ is given by the following equation from the trigonometric polynomial.

$$\hat{f}(\xi_1,\xi_2) = \sum_{n_1,n_2=0}^{N-1} f[n_1,n_2]e^{-2\Pi i(\frac{n_1}{N}\xi_1+\frac{n_1}{N}\xi_2)} \quad (9)$$

First, to compute

$$\hat{f}(\xi_1,\xi_2)\overline{V(2^{-2j}\xi_1,2^{-2j}\xi_2)} \quad (10)$$

In the discrete domain, at the resolution level j , the Laplacian pyramid algorithm is implemented in the time domain. This will accomplish the multi scale partition by decomposing $f_d^{j-1}[n_1,n_2], 0 \le n_1,n_2 < N_j - 1$, into a low pass filtered image $f_d^j[n_1,n_2]$, a quarter of the size of $f_d^{j-1}[n_1,n_2]$,and a high pass filtered image $f_d^{j-1}[n_1,n_2]$ .Observe that the matrix $f_d^{j-1}[n_1,n_2]$ has size $N_j * N_j$,where $N_j = 2^{-2j}N$ and $f_d^0[n_1,n_2] = f[n_1,n_2]$ has size $N*N$. In particular,

$$\hat{f}_d^j(\xi_1,\xi_2) = \hat{f}(\xi_1,\xi_2)\overline{V(2^{-2j}\xi_1,2^{-2j}\xi_2)} \quad (11)$$

Thus, $f_d^j[n_1,n_2]$ are the discrete samples of a function $f_d^j[x_1,x_2]$, whose Fourier transform is $\hat{f}_d^j(\xi_1,\xi_2)$. In order to obtain the directional localization the DFT on the pseudo-polar grid is computed, and then one-dimensional band-pass filter is applied to the components of the signal with respect to this grid. More precisely, the definition of the pseudo-polar co ordinates $(u,v) \in \mathbb{R}^2$ as follows:

$$(u,v) = (\xi_1, \frac{\xi_2}{\xi_1}), if(\xi_1,\xi_2) \in D_0 \quad (12)$$

$$(u,v) = (\xi_1, \frac{\xi_1}{\xi_2}), if(\xi_1,\xi_2) \in D_1 \quad (13)$$

After performing this change of co ordinates, $g_j(u,v) = \hat{f}_d^j(\xi_1,\xi_2)$ is obtained and for $l = 1-2^j,...2^j - 1$:

$$\hat{f}(\xi_1,\xi_2) = \overline{V(2^{-2j}\xi_1,2^{-2j}\xi_2)W_{jl}^{(d)}(\xi_1,\xi_2)}$$
$$= g_j(u,v)\overline{W(2^j v - l)} \quad (14)$$

This expression shows that the different directional components are obtained by simply translating the window function W .The discrete samples $g_j[n_1,n_2] = g_j(n_1,n_2)$ are the values of the DFT of $f_d^j[n_1,n_2]$ on a pseudo-polar grid. That is, the samples in the frequency domain are taken not on a Cartesian grid, but along lines across the origin at various slopes. This has been recently referred to as the pseudo-polar grid. One may obtain the discrete Frequency values of f_d^j on the pseudo-polar grid by direct extraction using the Fast Fourier Trans-form (FFT) with complexity $ON^2 \log N$ or by using the Pseudo-polar DFT (PDFT).

5. PROPOSED METHOD

The proposed contrast image enhancement approach using DST and GA is shown in Figure 4. It includes

- RGB to HIS Conversion
- DST Decomposition
- Intensity values are modified by Chromosome of Genetic Algorithm.
- DST Reconstruction
- HSI to RGB conversion

Figure 4 shows the DST and GA based proposed image enhancement approach.

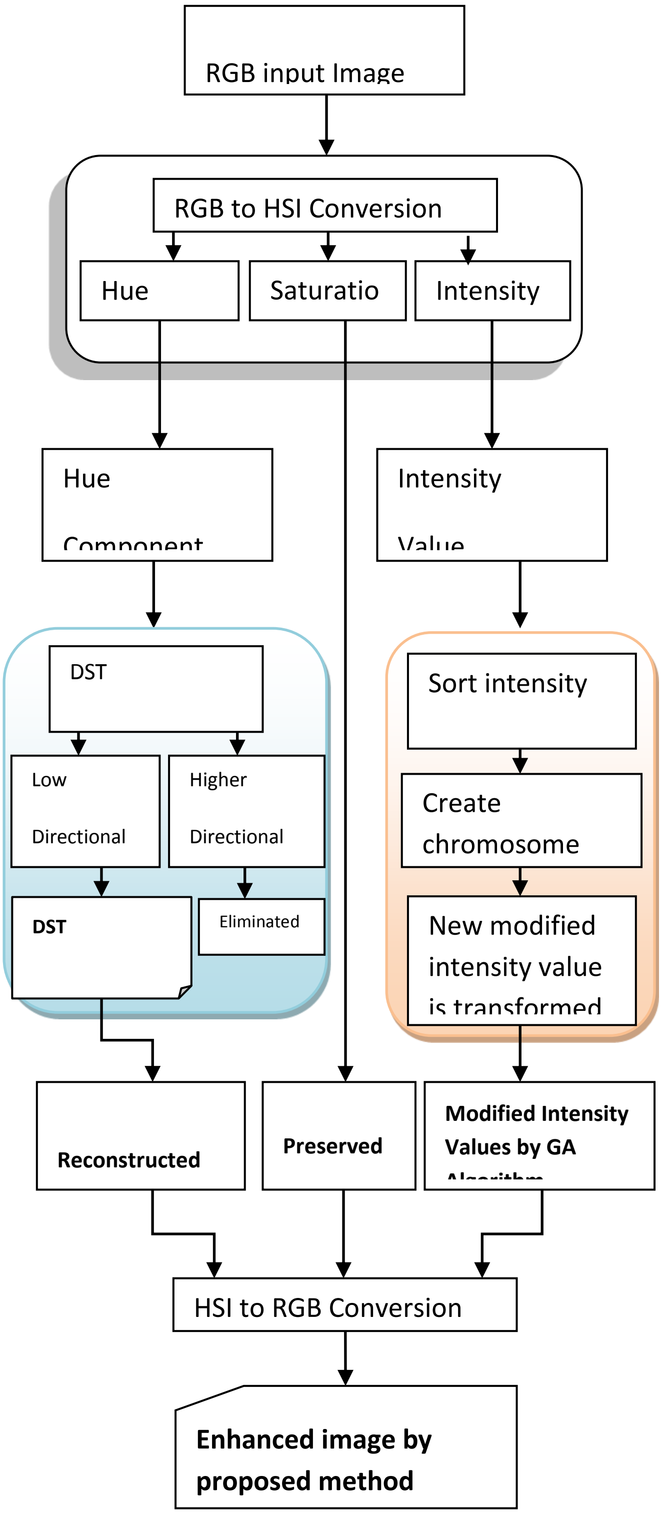


Figure: 4 Block diagram of the proposed image enhancement system using DST and GA

The input RGB image is initially, converted into HSI model. Further hue and intensity components are used as the inputs for the proposed resolution enhancement process. Hue is decomposed by DST at 2 levels with 2 directions, which produces five shearlet bands, includes four higher sub-bands and one lower sub-band. The decomposed lower frequency is alone taken into the account for inverse shearlet transforms. Then intensity values are transformed by using Chromosome array values, which is obtained from input image using genetic Algorithm. Finally, the HSI model (modified Hue by DST and modified Intensity values by GA and preserved Saturation) which are converted into RGB model to obtain enhanced image.

6. EXPERIMENTAL RESULTS

In this section, to demonstrate the performance of the proposed algorithm, the proposed method is compared with other image enhancement techniques in terms of ability in contrast and detail enhancement, the proposed method to produce natural looking images. Histogram equalization [1], are contrast enhancement methods which are used for comparison. In this study, the proposed method was simulated on 512 * 512 images.

(a)

(b)

(c)

(d)

(a)

(b)

(c)

(d)

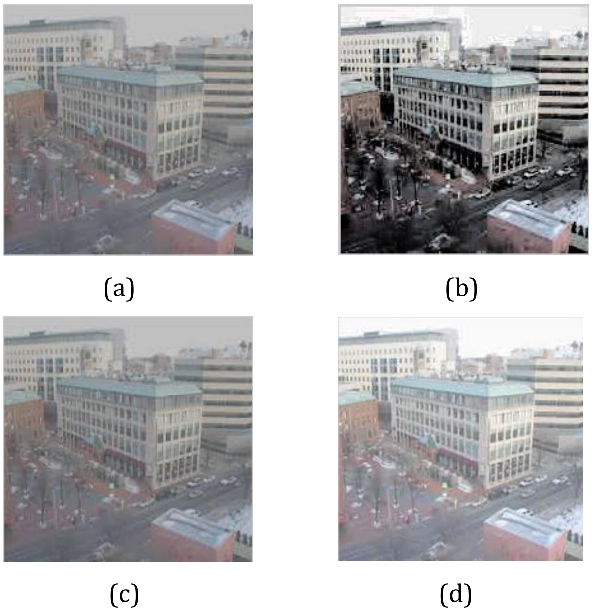


Figure: 5 Comparison of proposed technique with Histogram equalization method and DST (a) Input Image (b) Histogram equalization image (c) Discrete Shearlet transform (d) Proposed Technique

3. CONCLUSIONS

A novel approach for image enhancement has been proposed in this paper based on discrete shearlet transform and Genetic Algorithm. Initially, the color image converted into HSI model. In order to improve the contrast of the image, the hue colour and intensity channels only considered. The shearlet decomposition produces and low and high directional sub bands on the hue channel. The lower directional sub band is used for inverse shearlet transform to reconstruct the Hue channel. Intensity value is transformed by Genetic Algorithm and saturation is preserved. Then, the enhanced image is obtained by converting HSI to RGB model. The satisfactory result is achieved from the proposed DST and GA based image enhancement approach.

REFERENCES

[1] R.C Gonzalez, Digital image processing prentice hall of india, second edition,2006
[2] Laine .A, Hudu.W enhancement by multiscale non linear operators, handbook of medical imaging, academic press.,2000
[3] Fan-chiehcheng "color contras enhancement using automatic weighting mean-separated histogram equalization international journal of innovative computing, information and control vol 7,No.9,2011
[4] D.J jobson, Z.Rahman and G.L Woodell, "A multiscale retinex for bridging the gap between colour image and the human observation of scenes" IEEE Trans. image process vol.6. No.7 pp.965-976.jul 1997
[5] G.orsini, G.Ramponi, P.carrai and R.Difederico "A modified retinex for image contrast enhancement and dynamics control," inproc.Int.conf.image process., vol.3.sep 2003. pp.393-396
[6] R.Sobel. "Improving the retinex algorithm for rendering wide dynamic range photographs " J.Electron image, vol.13 No.2,pp 65-74,2004
[7] L.Tao and v.Asari, "Modified Luminance based MSR for fast and efficient image enhancement ",in proc.32nd appl.
[8] T.watanabe, Y.kuwahara, A.kojima and J.kurosawa."An adaptive multi-scale retinex algorithm realizing high colour quality and high speed processing" J.Image.sci.technol. vol.49.no.5. pp 486-497,2005
[9] D.heric, B.potocnik "Image enhancement by using Directional Wavelet Transform "Information Technology interfaces ITI=2006, PP.201-206,2006
[10] S.Premkumar, K.A.Parthasarathi, "An Efficient approach for colour image enhancement using discrete shearlet transform"ICCTE-14 IEEE conference pp.363-366, July 2014.
[11] C.Munteanu, A,Rosa, "Towards automatic image enhancement using genetic algorithm", Proceeding of the congress on evolutionary computation, vol2 2000, pp.1535-1542.
[12] F.Saitoh, "Image contrast enhancement using algorithm", IEEE International conference on systems, man and cybernetics, volume 4,1999 pp:899-904.
[13] Sara Hashemi, Soheila Kiani, Navid Noroozi, Mohsen Ebrahimi Moghaddam, "An image enhancement method based on Genetic Algorithm", IEEE International conference on Digital Image processing 2009 pp: 167-171.